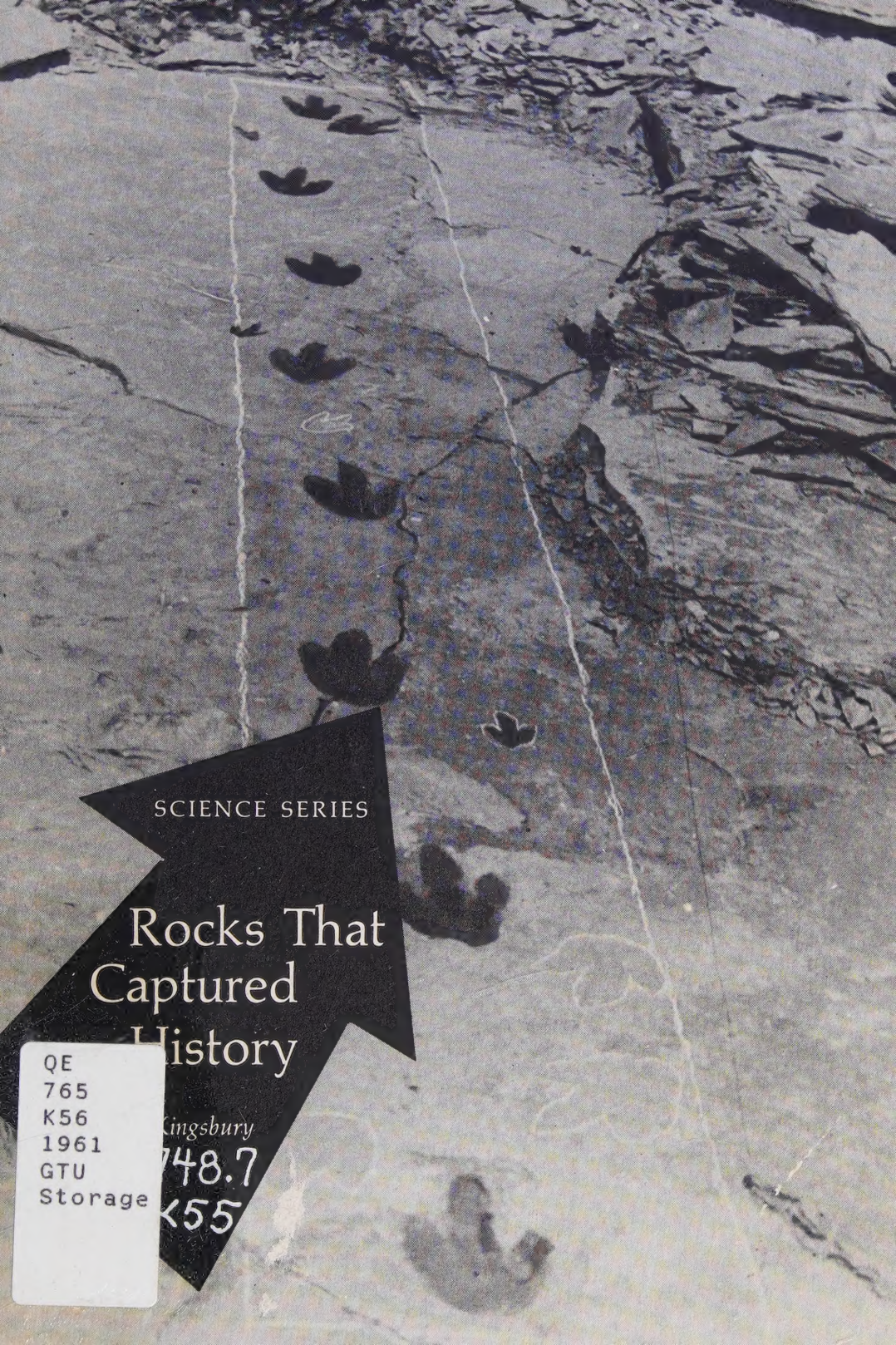

SCIENCE SERIES

Rocks That Captured History

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Errata: In the last paragraph on page three substitute *sixty million* for *a million* each time *million* appears in the first four lines.

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Rocks That Captured History

By Edith C. Kingsbury

Beacon Science Series

Beacon Press Boston

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1. Sea Shells in Rocks!

Could a sea shell be found in a rock far inland? People who live in some cities in Ohio walk on sea shells every day, sea shells in the stone slabs that form their sidewalks! If you live in New York, Ohio or Illinois you may have found many rocks with shells in them. How *could* a sea shell be found in a rock so far from the sea? Was it washed in from the ocean by a giant wave? Did someone put it there as a joke? Scientists know that you find these shells in rocks far from the ocean, because the animals inside those shells lived very near where you are finding them today. When they were alive, what is now dry land was an inland sea.

Long ago — many millions of years ago — the sea may have covered the land where you live. Mountains rose slowly for millions of years and then were slowly worn away. The land between the mountains sometimes rose and sometimes fell. The earth's great seas rose and fell. And when the land fell below the level of the sea, the sea covered the land. This happened not once but several times, sometimes in one part of our country, sometimes in another, and sometimes more than once in the same place. Of course, this happened all over the world, but in this book we are thinking about the land in North America.

The seas that covered parts of our country were shallow. There were many animals that grew shells for houses living near the shores of these inland seas, much as similar animals live in our oceans today. When these animals died, their shells dropped to the bottom of the sea or were washed onto the shore. These shells were slowly covered with mud or sand, covered deeper year after year. Sometimes the water contained lime, and the sand or mud was cemented together, forming limestone. Shells in the sand or mud became part of the stone. Sometimes the shell itself was slowly dissolved and washed away, and sand or mud would fill the space, but often the perfect shape of the shell remained.

Sometimes these rocks with shells in them were lifted up by forces deep inside the earth; sometimes layers of mud on top of them were worn away. Some gradually came to the surface, permitting us to see for ourselves the shells of animals that lived millions of years ago.

Many of these ancient shells are not like the shells you find on

beaches today. Some had two shells for each animal — as a clam does today — but the animal was much simpler than the modern clam. These are called lamp shells, although their real name, the one you will find used in many books about fossils, is *brachiopod.* One shell would often have a swelling in the center section, and the other an indentation to match it. People who found these shells thought they looked like oil lamps and called them lamp shells, although there were many brachiopods that did not look a bit like a lamp. There are a few lamp shells living today, descendants of those that lived so long ago.

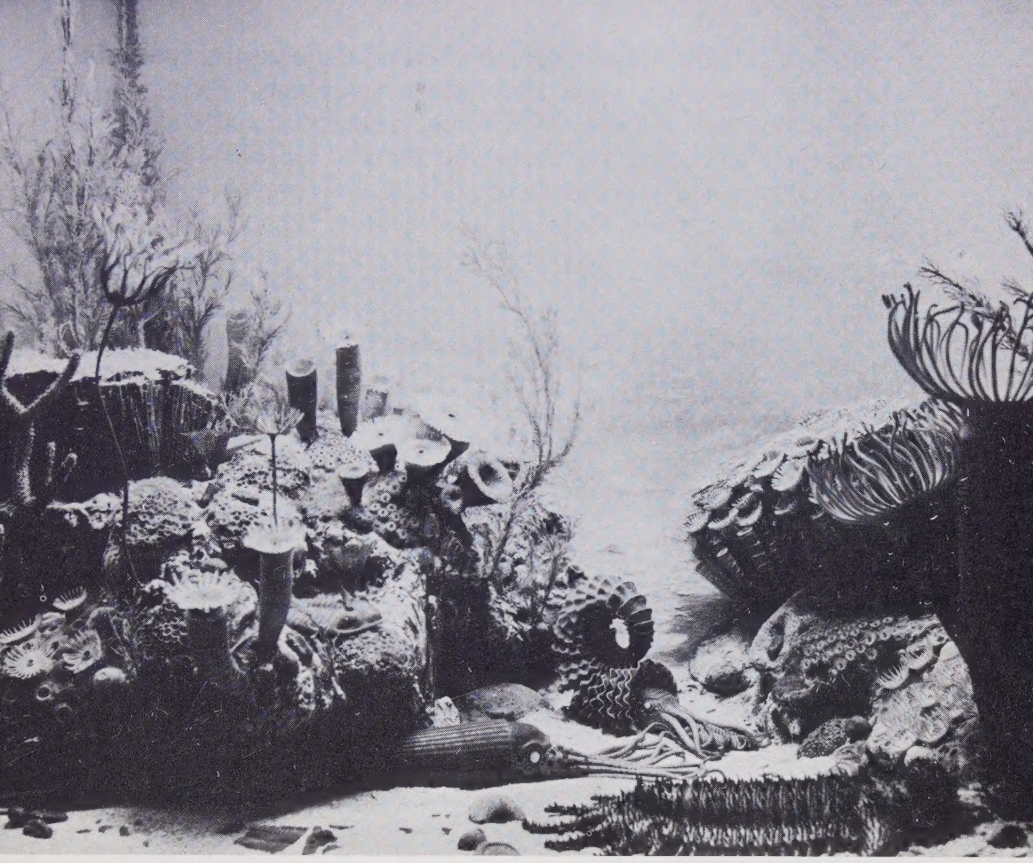
Spiriferoid Brachiopod

There were some snails, clams, scallops and oysters living in these ancient seas, but they were not as common as brachiopods. Scientists believe that the last inland seas covered our land about 200 million years ago. The chances are very great that any fossil sea shell you find is at least as old as that, and may be far older. This picture shows what the bottom of the sea probably looked like 500 million years ago!

Whenever you hear about fossils (or dinosaurs) you hear that they lived millions of years ago. A million years is a long time. It is hard to think how long a million years might really be. Think for a moment how long the time seems from one birthday to the next; or from one Christmas to the next. A *whole year* is a long time. Try to imagine a *million years!* You can't really do it, can you?

Now let's watch the second hand of a watch or clock go around once, and pretend it took a year for it to move through the sixty seconds. That is not so hard to imagine, is it? Think about the time you have been living, maybe about ten years. This is really a long time, so long that you cannot remember it all. Watch the second hand again (remember sixty seconds stands for one year) and let it go around ten times. Ten minutes is a long time to sit and watch a second hand. See how much longer it seems than the one "year" did.

Now let's think about one hundred years. A hundred years ago there was no radio and no television. There were no automobiles or



Reconstruction of Devonian Sea
Courtesy University of Michigan

telephones. It was a very different world from the one you live in today. A person who lives to be a hundred years old is considered to be very old. A hundred years *is* a very long time. Watch the second hand again, but we won't even try to sit this long! For you would have to watch the second hand go around for an hour and forty minutes to have one hundred of these sixty-second years.

Perhaps now we can *try* again to imagine a million years. It was a strange world a million years ago. There were dinosaurs, but no men. Most of the animals we know today had not developed yet. In the million years we are trying to imagine, many other animals developed and then, like the dinosaurs, were not able to survive when conditions on the earth changed. You would have to watch the second hand a year and three hundred and thirty days — or nearly two whole years — for it to go around enough times to be a "million years"!

Ancient animals called *trilobites* lived on the earth, maybe near where you are living, some 500 million years ago. That is 500 times as long as a million. You would have to sit and watch the second hand go around for about 980 years to represent how long a time 500 million years is! Even this is really impossible to imagine. And remember, the earth itself is older than this.

Middle Devonian Trilobites
Courtesy of the American Museum of Natural History

Before we talk more about fossils, would you like to try to make something that is very like a fossil? It may help you to understand what they are. Fossils are made in many ways in nature, but the two commonest forms are the *cast* and *mold*.

When a shell is buried in the sand or mud it often makes a mold of the outside of the shell. If the mud hardens and becomes rock, this is a fossil imprint or mold. Sometimes the water seeping into the rock will dissolve all or part of the shell inside the mold. Now this space may be filled with more silt and mud and this, too, may harden into stone. This makes the solid form of the shell, with most of the original detail of the shell, but this time it is made of rock, not shell. If you press your hand into some soft clay, you leave a *print* of your hand. When the clay hardens you have a *mold* of your handprint. Now oil this mold and pour in plaster of Paris and let it harden. When you lift the plaster out of the clay mold, you have a *cast* of your handprint.

To Make "Fossil" Molds and Casts

1. Choose the things you would like to make into "fossils": it may

be a fern, or the branch of a tree that has rough bark or scales, or a snail shell.

2. To make the mold, roll out some plasticene flat and smooth. Take a small frond of a fern (or any other things you want to use), and place it on the clay with the heavy ribbed side up. Place a piece of cardboard over it and press it carefully into the clay. Then remove the cardboard. (If it is a shell you need only to press it in to make an impression, then remove it before you pour the plaster.) Cut the clay into a neat circle, oval or square, and put a cardboard collar around the clay, extending a half inch or so above the clay, and fasten it with a paper clip or masking tape. Then carefully pour a mixture of plaster of Paris into this mold. Let it harden for several hours, then remove the cardboard collar and carefully pull off the clay. This should give you a mold with the same lovely detail you see in a real fossil that may be more than 200 million years old.
3. If some of you want to make casts, you will have to use a mold to do it. Put some vaseline or lubricating oil into the mold and see that it gets into every crack and crevice. Make another collar and pour plaster into this just as you did to make the mold. When it hardens, you will have a cast. Tap and pry gently to get them apart. Sometimes when you break open a rock, you will get both a cast and a mold of the fossil inside it! When the casts and molds are done, look at some real fossils and pictures of fossils. Notice how different each of these is. After you have looked at them, pretend that you are a scientist who has just found one of these fossils. Make drawings of the ones that you like the best and copy the name of the fossil from the picture or the card. Do you want to try to say any of these names? They are hard to read or write or say.

Things to Do at Home

1. If your "fossil" was not hard enough to take apart, take it home and finish it there. Perhaps your father or mother will help you mix some plaster to make more casts and molds.
2. In Parker's *Stories Read from the Rocks* (see bibliography) there are maps of the inland seas on the inside of the back cover. See if you lived where the inland sea once was, or if you know anyone who does. If you do know someone, perhaps you could write and ask them to see whether they could find some fossils for you. Perhaps you live where your parents could take you hunting them for yourself.

2. More About Fossils

Many of the plants and animals which became fossils are now extinct, which means that there are no longer any of them living. The only way we can know that they did live is from the remains left behind in mud that hardened into stone. But scientists have worked for many years studying these fossil remains. They have fitted the bits of knowledge together almost the way you might put together a jigsaw puzzle. Many of the pieces are still missing, but there are enough to know which living things were the earliest forms of life on our planet and which developed later.

In the center of this book (so that you can open it up and see it clearly) is a chart showing the order in which the scientists think life on earth developed. The chart will show you when some of these living things were most important and most powerful. People are *now* the dominant form of life on earth, but this has been true for only the last few hundred thousand years, As you can see by studying the chart, life of one kind or another has been on the earth for a very long time.

Study the chart and talk about it; look in the various books you have for clear pictures of the different plants and animals shown in silhouette on the chart. *The World We Live In* is one book where you will find fine pictures. Your class can make a big copy of the chart, showing the animals, and hang it on one of the walls of the class room. If yours is a big class, you may want to divide into committees and let each committee make a special part of the chart.

When you have finished, explain the part of the chart you have drawn, and give reports about things you discovered while you were working on it. When you see the number of million years ago each of these kinds of animals lived, remember the work we did with the "one-minute years," and see if you can imagine how very long ago these creatures lived (and how long each kind of animal lasted).

Fossils tell so many stories. The fossils we find in different places help us to learn what that part of the country was like long ago. They tell us about the plants and animals that lived long, long ago.

Scientists have spent years learning to "read" the stories in rocks. The chart will help you to "read" the fossils that you may find, or borrow, or see in a museum.

Look at the chart again. Such strange names for the different

periods of time! Paleozoic, Mesozoic and Cenozoic are some of these names. Do you notice a part of each of these words that is the same? "Zoic" comes from a Greek word meaning *life,* so we have Paleo-life, Meso-life, and Ceno-life. What do the other parts of the words mean? *Paleo* means "ancient," *Ceno* means "new," and *Meso* means "middle." Now do you see how easy it is to "translate" these names of the eras? Era means a period of years. Cambrian is the name given to the very earliest part of the paleozoic, and *pre* means before. So Pre-Cambrian means before the very ancient times; only the very simplest of life existed then; the Pre-Cambrian era is *more* than 500 million years ago.

When scientists in different parts of the world were studying they discovered a remarkable thing. Layers of rock in England had fossils of shells almost like some of those in New York State. Skeletons of certain kinds of ancient fish have been found in many parts of the world. Fossils are usually found in layers, one on top of another. The scientists found that the order of the fossils in the layers of rock was the same in many parts of the world, certain kinds of rocks usually having certain kinds of fossils. So they started fitting this fact into their "jigsaw puzzle."

After much digging, collecting, studying and comparing of notes, they came to a general agreement as to the order in which life had developed on the earth. To make it easier to talk about the various periods of time, they gave them names. Putting dates on these times was much harder to do. They had to keep changing their dates as new facts were discovered. The world was far older than they had imagined it to be. But it is safe to give names to the ages that have similar fossils, and sometime we may know all of the real dates.

Look at the chart again and think of the many forms of plants and animals that have lived. Think how long there has been life on this planet, and how many different kinds have appeared, lived for millions of years and then ceased to be. Yet each of these forms of life is in many ways related to the life that has gone before it, and probably many forms of life that we cannot even imagine are yet to be! *Life* in its many forms, in its ever-changing varieties, *life* enduring over millions of years even though no single life, or very few forms of life, can last so long. What a very great wonder this is!

Things to Do at Home

1. You can do an experiment that will show you how dirt and rocks settle out of water. Take an empty glass quart jar and fill it about half-full of coarse dirt (dirt with some little pebbles in it); if you have a shell or two, put those in as well. Then fill

it almost to the top with water and shake it till it looks muddy. Leave it where you can watch it for a few days: you will see it settling into layers. Watch especially to see where your shells settle. Of course, yours won't turn into sedimentary rocks! But it will give you some idea of how things settled down onto the bottom of the inland sea. Draw a picture of your jar and its layers. It will take several days for the water at the top to be entirely clear.

2. If you live in an area where there are many rocks, see if you can find some that are limestone. Put your stones or rocks into hot vinegar; if they are limestone, then you will see bubbles forming and rising to the top of the water.

3. Seashores on Mountaintops

We have studied the inland sea that covered much of the central part of our continent several times. Since no people were living in those days, how can we know? This is the story of a man who helped to prove that North America had an inland sea and saw how a shallow sea could have left shells on mountain tops!

James Hall's Lifelong Curiosity

James Hall was born in 1811 on the seacoast of Massachusetts. Here he often played on the beach, and as he grew older he began to collect sea shells. In grammar school he found a teacher who shared his interest. Together they spent many hours studying shells and other forms of sea life.

At the age of nineteen Hall decided to spend his life studying what in those days was called "Natural History." At first he did not know where to study, but he heard of a school in Troy, New York. Here science and natural history were taught, not just from books, but by going out to study nature at firsthand. It seemed just the school he wanted. Because he had barely enough money to pay his tuition, he walked the 220 miles to Troy in order to study!

Geology sounded most interesting to him, and he found the trips to study rock formations fascinating.

Having no money and no job when he graduated in 1832, he was discouraged, but the director of the school urged him to stay in Troy. He found odd jobs to earn enough to live, and soon the college asked him to teach. In three years he became a professor. The next year the state of New York began a geological survey (making maps of rock formations all over the state), and Mr. Hall was made an assistant.

Hall was put in charge of the survey of western New York, a level wilderness of ten thousand square miles. Traveling through this area he began to find fossils that could only be signs of sea life — so many fossils that they seemed as numerous as pebbles in a stream bed. He collected thousands of fossils. He dug down into layer after layer of rocks and made charts of the order in which he found the fossils. The lower layers had fossils that were not like the ones above them. But he discovered that wherever he dug into layers, the order was the same.

Because he was so interested, Hall was sure other people would be, too. He made a very complete report about the fossils and had it printed with many fine illustrations. The state legislature, which had to pay the bill, thought he had spent far too much money on things that were not important, and he was scolded severely for it.

The legislature might think it was a waste of money to publish the fossil book, but scientists from all over the world thought Hall's reports were most valuable.

Now, while finding his fossils, he noticed ripple marks in stone, much like the ripple marks you see on the shore at low tide. Can you imagine how excited he became as he found these in several places! This very land, he decided, must have been the shore of an ancient sea.

He found stones with ripple marks made by tides near the shore and reefs of coral in the deeper waters off the shore. He realized that there was little coal in the state (coal was what the legislature wanted him to find), because he found no signs of the ancient kinds of swamps where coal was formed. This did not please the legislature; they wanted coal and all Hall found was fossils.

Hall quarreled not only with the legislature but also with other scientists. He decided that the two borders of the ancient sea were where the Appalachian Mountains and the Rocky Mountains now stand. He reasoned that the mountains were probably formed because a great deal of sediment had piled up at the edges of the sea, and that this sediment became so heavy it caused the earth to sink until finally the land buckled and the mountains were pushed up. This would explain something that scientists had never understood: why there were so often fossils of sea shells, fish, or other evidences of sea life on mountain tops. Hall's explanation of how the mountains were formed would explain this ancient mystery. But the scientists were not yet ready to accept it.

His friends begged him not to keep talking about this theory for fear he would ruin his career. But Hall could not keep silent about what he thought was truth. He kept right on talking! And gradually over the years most people have come to believe Hall's solution to the mystery.

Things to Talk About

1. Suppose you were sure that some idea you had was true, and your friends laughed at you and called you foolish. Would you keep on believing it? Can you imagine how you might feel if your friends refused to have anything to do with you? This

has happened to many scientists. Do you suppose they feel as you do?

Things to Do at Home

1. If you live near a lake or pond, visit it with some older person during the week and see if you find present-day ripple marks.
2. If there is a heavy storm during the week, hunt for mud puddles after it is over. See if you can find signs in the mud of rain drops or a few ripple marks. Look at them carefully and report *all* you can see. This is practice in careful observation and record making. It is part of what every scientist has to learn.
3. If you take a tube of paste, or a plastic bag filled with plasticine (close the bag thoroughly with a rubber band), and lay it on a table and press down in the middle, you will see how this pushes the material up on either side. This will show you, roughly, how the weight of sediment was able to "push up mountains."

4. Footprints in Stone

One morning in 1802, Pliny Moody went into his fields in South Hadley, Massachusetts, to plow as usual. But this morning his plow dug deep and suddenly caught some shale which broke and came to the surface. Bending over to throw the pieces out of the way he found to his amazement what looked like footprints of some four-toed animal, different from any footprints he had ever seen — not footprints in mud or snow, but footprints in solid rock. He lifted out first one piece and then another. Where the stone had split he could see more footprints. Some were only four inches or so across and some were more than a foot, but all were four-toed and very clear. What animal could have made footprints like this, and in solid rock?

None of his neighbors had ever seen anything like them. People started hunting on their own land, or came to look where Pliny Moody had found his. Soon they found footprints with three toes. Finally they decided some ancient giant bird must have made them. They called them the "tracks of Noah's Raven," thinking it must have been the raven which came out of Noah's ark after the great flood!

Years later, scientists realized that these were the footprints of ancient reptiles. Footprints, not of Noah's Raven, but of early dinosaurs of the Connecticut River valley. They think that these footprints were made in soft mud and hardened into stone more than 100 million years ago. (See cover picture.)

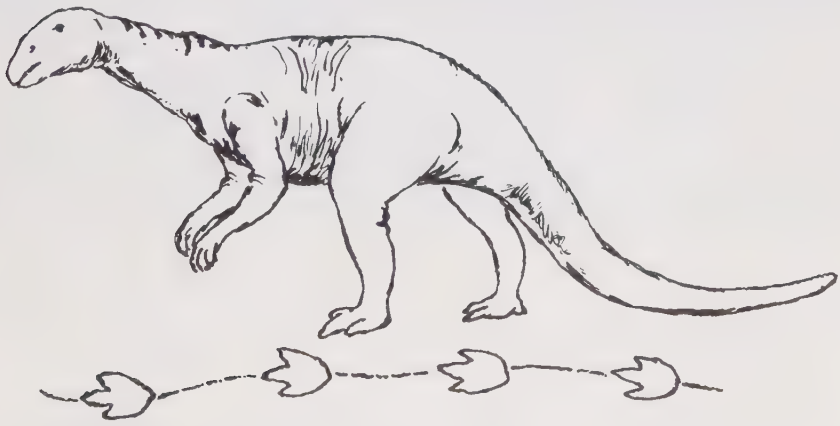
In those ancient times the land where Pliny Moody's farm now stood must have been a watering place for dinosaurs. The bottom of this pond and the land at the edge were probably sticky mud or clay. The area was getting drier then, so during the dry seasons the mud on the shore would bake hard. Then the rains would come; the streams which fed the pond became torrents, and the land would flood. This new mud would bake hard in the next dry season, then rains would come again; the reptiles would make footprints, and the mud would harden once more. Year after year footprints dried into the mud, were covered with silt, and built up layer after layer which finally became solid stone filled with dinosaur tracks.

Dinosaur tracks made in this way are found in many sections

of the country, but this is the story of how they were discovered in the Connecticut River valley. Some were found while engineers were laying tracks for a railroad along the river. These were dug out and sent to museums and colleges in Massachusetts. Some which they did not have to move can still be seen along the railroad right of way.

Over a hundred years after Pliny Moody found his tracks, Carleton Nash and his brother were looking for dinosaur tracks in the fields. They found a field in which there were some fine tracks. Here the shale was easily broken into layers, and as they pulled up the top footprints, there were more underneath. They looked around the field and found more tracks — more dinosaur tracks than they had ever seen before. This must have been a real gathering place for dinosaurs. How they wished they might own this field!

When Nash grew older he *did* buy the field. Then he went to college to study geology and learn about life in those ancient days. Today the land is open to the public so that boys and girls can walk where the dinosaurs walked 180 million years ago. Nash splits off layer after layer of dinosaur tracks and sells many of them. Most of the tracks are three-toed, probably from smaller dinosaurs, perhaps four or five feet tall. There are also some larger tracks made by heavier dinosaurs.



Gigandipus Caudatus
After Fig. 159, Bulletin 81, Triassic Life of the Connecticut Valley. *Used by permission*

These tracks were buried by layer after layer of mud that turned to stone. Many of them must have been far under ground. Over the ages some of the rock has warped and tilted. Some that

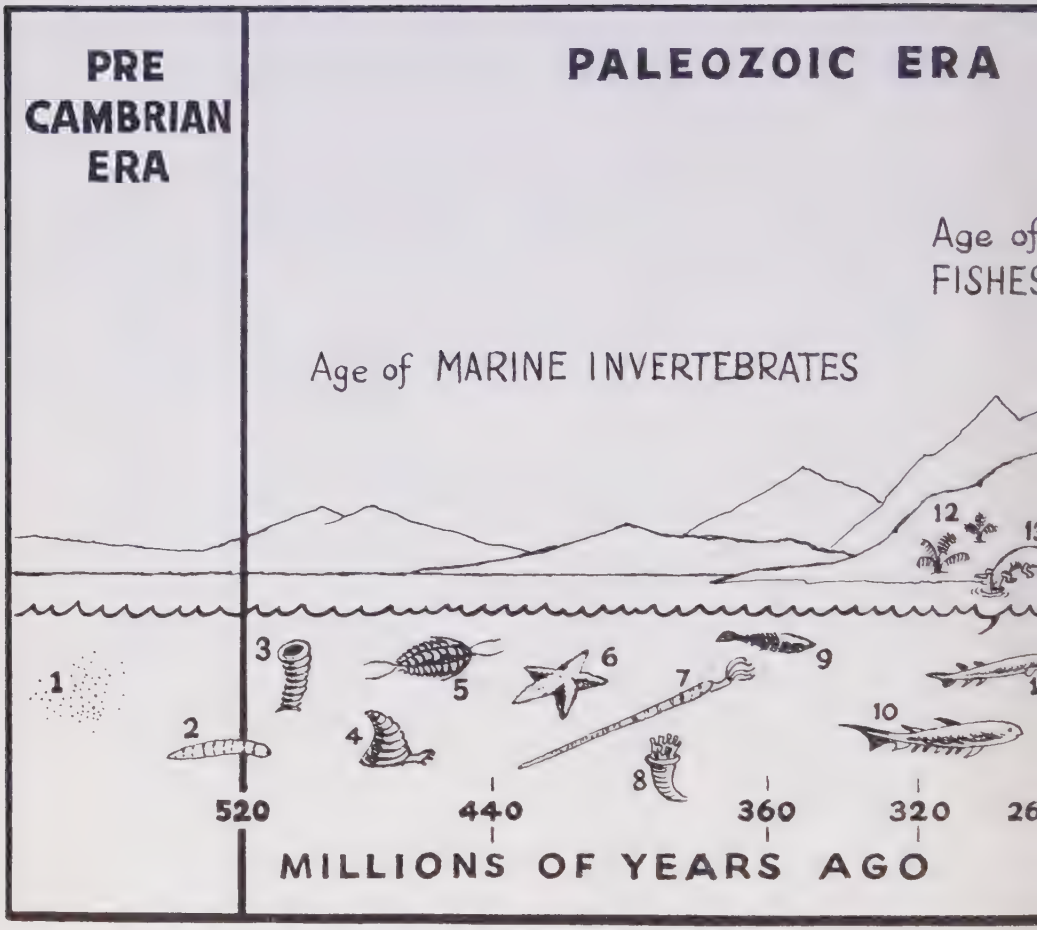
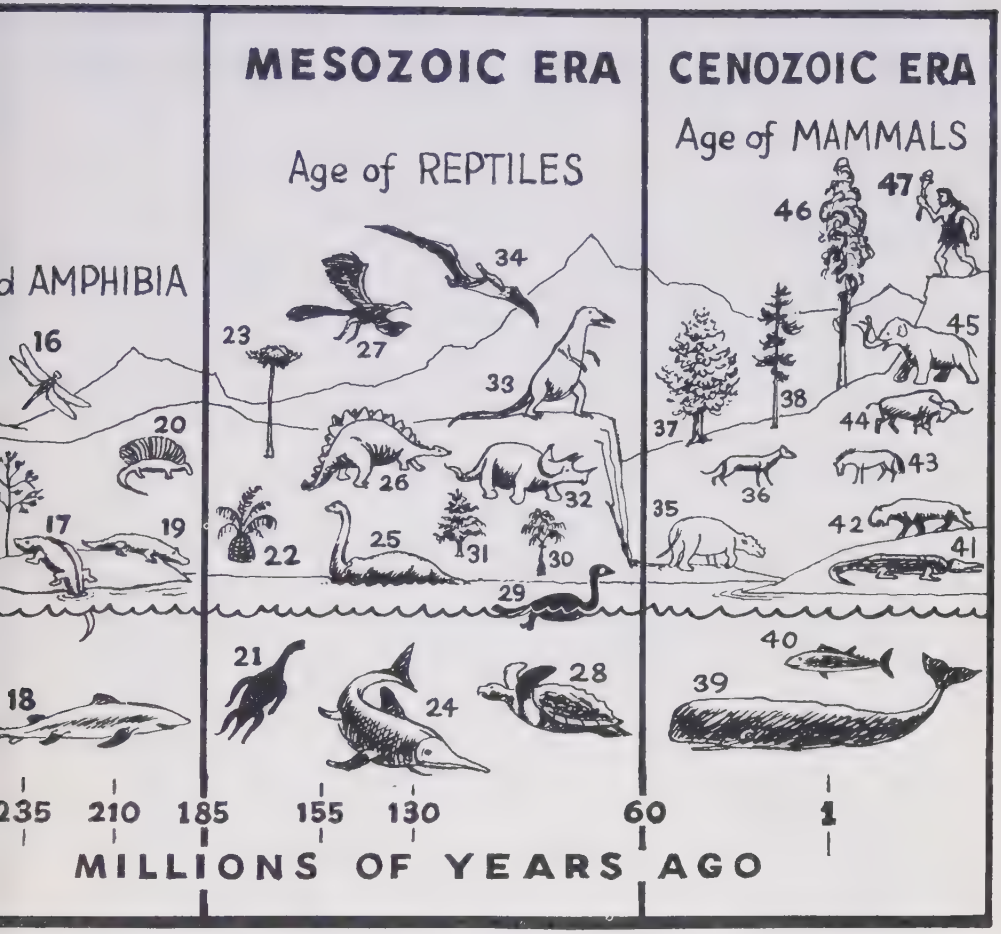


Chart adapted by permission from The National Geographic

Key:

1. Microscopic Algae
2. Segmented Worm
3. Archaeocyathus
4. Snail
5. Trilobite
6. Starfish
7. Giant Nautiloid
8. Coral
9. Heterostracan
10. Acanthodes
11. Osteolepis
12. Ferns
13. Ichthyostega
14. Lepidodendron
15. Calamites
16. Meganeuron
17. Eogyrinus
18. Shark
19. Seymouria
20. Edaphosaurus
21. Plesiosaur
22. Cycads
23. Araucarites



24. Ichthyosaur
25. Brontosaurus
26. Stegosaurus
27. Archaeopteryx
28. Archelon
29. Hesperornis
30. Palm
31. Ginkgo
32. Triceratops
33. Tyrannosaurus
34. Pteranodon
35. Uintatherium
36. Mesohippus
37. Maple
38. Pine
39. Whale
40. Bluefin Tuna
41. Crocodile
42. Saber-toothed Cat
43. Equus
44. Bison
45. Woolly Mammoth
46. Sequoia
47. Man

were deeply buried came near the surface, and footprints have been exposed. There must be thousands of tracks still buried deep underground. For some reason the mud of the Connecticut valley was not good for preserving the dinosaur bones. A few have been found, but most of the information we have of these dinosaurs has been learned from studying their footprints.

Making Fossil Prints

Let each member of the class make a fossil handprint of his own hand. It will be simpler to do this if self-hardening clay is used, so that each person can just push his hand into a layer of it, and then let the impression harden. But it can be done by making casts and molds as was done in session one.

Things to Do at Home

1. Of course, we can't all go out and find fossil footprints. But if there is mud or snow in your neighborhood you can go out and find footprints of many kinds. Dogs, cats, mice and birds leave their prints, even in the largest city. Try to draw the footprints you find.

5. The Tar Pit's Hoard

One of the best places to see the actual bones of fossil animals is at the Rancho La Brea, outside Los Angeles, California. Early in the 1900s a rancher started to sell tar from some of the deep tar pools on this ranch. The tar was needed, so many orders came in. The ranchers had trouble digging the soft tar because it was full of animal bones which kept slowing up their work. The men pulled out as many of the bones as they could and piled them in great heaps by the tar pits.

About 1906 some scientists heard about the bones and came down to the ranch to study them. They started to assemble some of the bones into skeletons and to their surprise found that many were actual bones of animals which had been extinct for thousands

Reconstruction of La Brea Tar Pits
Courtesy of Los Angeles County Museum

of years — such as the famous saber-tooth tiger! There were huge vultures with a wing spread of ten to twelve feet, giant mammoths, ground sloths, lions and hundreds of antelopes. The soft tar had preserved the bones perfectly for thousands and thousands of years.

How had these animals, so wise in the ways of nature, come to fall into the pits? These pools of tar became warm, soft and sticky on hot days when the sun beat down. From a distance they sparkled as though they were pools of water, and animals from miles around came for water. Often there must have been a thin layer of water on top of the tar. A thirsty animal would go out on the edge to get a drink, go a little too far, and a foot or a hoof would be stuck. He went in deeper trying to free the foot but, like tar baby in the Uncle Remus story, he just became more and more bogged down. He must have cried for help and thus attracted the larger meat-eating animals. They, in turn, were tempted out onto the sticky tar to make a meal of the helpless animal and, being even heavier than the first, were quickly, hopelessly stuck themselves.

Some of the tar pools, and also some of the bones that were in them, may be seen today in Los Angeles. There are still pools in the area, and hardly a day goes by that some unwary calf or wild animal is not pulled to safety by the ranchers. But in the days so long ago, when the ancient animals got stuck, there were no ranchers to help them out.

For a long time the *paleontologists* (the long name for scientists who were studying fossil bones) were puzzled by the fact that the bones came from either very young or very old animals. But they realized, after watching the animals of today, that many young animals start to get stuck and manage to free themselves. However, if they were very young and not yet strong, or very old and becoming weak, they would not have the strength to pull themselves out. Thus the tar pits gathered bones and became our source of knowledge about many creatures.

Among the animals trapped at La Brea were mastodons, woolly mammoths, giant sloths, saber-toothed tigers and cave bears. Paleontologists tell us that it must have been about eleven thousand years ago when these animals were trapped at La Brea.

The picture of the tar pit in this lesson is one artist's idea of what it looked like (and our picture is only part of what he drew). Why not look up some of these animals to learn more about them and then make *your* picture of La Brea? You could do it as a large class mural, or you could make individual pictures.

Things to Do at Home

1. La Brea has sometimes been called "The Deathtrap of the Ages." You could imagine that the tar pit could tell its own story, and make pictures to go with your story.
2. If you have an encyclopedia at home or at school (or your parents could take you to the library), you might see how much you can find out about the animal of the tar pit that you think is most interesting. You could either write out what you find, or tell it to the group next week.
3. Perhaps you would like to take modeling clay and make a three-dimensional scene of the tar pits. These would be interesting animals to try to model if you have a picture to help you.

6. What Scratched the Rocks?

Are rocks hard or easy to scratch? Let's find out for ourselves. Look at the big rock your teacher brought this morning. What do you think might scratch it? See if you can make deep scratches or grooves that are easily seen.

Hard as it is to make even a little scratch on a rock, you will find — if you go out in the fields in many parts of our country or in Europe — rocks with deep, noticeable scratches and grooves all going in the same direction. For a long time no one could figure out what had made these scratches; it was one of the mysteries of science.

Glacial Groves
Courtesy of the American Museum of Natural History

About a hundred years ago scientists decided that the rocks had been scratched by glaciers. Glaciers are made of great sheets of ice. Ice that came down over the country pushing, slipping, sliding — tons and tons of ice: ice that moved over the rocks and ledges with a terrible force thousands of years ago. Many stones would be frozen on the underside of the glacier, and as the

whole mass moved, slowly but with great force, the stones on the bottom made the scratches or grooves in the rocky ledges beneath.

Glaciers form when the snow piles up so deeply in the winter that it does not all melt the next summer. The next winter more snow is added, and each year the glacier grows thicker. In the summer some of the snow on top melts, and the water from this melting snow soaks down, and at night when the sun goes down the whole mass freezes. Gradually it turns to solid ice — sometimes ice as much as a mile thick! Glaciers are like great rivers of ice moving slowly over the land.

Louis Agassiz was born in Switzerland in 1807. He loved the Alps, with their rivers, their meadows and their many glaciers. When he became older he studied medicine, but some of Louis Agassiz's friends were particularly interested in glaciers. They had come to believe that the rocks and boulders strewn over the fields were left behind by ancient glaciers that must have once covered all of these valleys.

In those days people were taught that the earth was exactly as it had been since the Flood, the flood written about in the Bible. They believed that all living things were descendants of those Noah took with him onto the ark. The fossil skeletons of queer fish and monsters, unlike any living in their world, confused these people. The idea that the land might once have been covered by deep glacial ice really shocked them. These things could not be true, they said, for if they were then the Bible itself could not be true.

But Agassiz and his friends kept right on believing that glaciers had covered Switzerland. Finally, after doing many experiments, they were able to prove that the glaciers *did* move, that they always moved *in the same direction* and that they *scratched the rocks underneath!*

Agassiz, who was now a famous man, came to Boston to lecture. Then he became a professor at Harvard University and spent the rest of his life in this country. He never forgot his interest in fossils or in glaciers, and many of his students went on to study them, too. So it was that even the scratches on rocks came to tell us more about the history of the past! Study the map on page 28, and see if your state was covered by the glacier. If not, how near did it come?

Things to Do at Home

1. Look up the stories of the Flood in the Book of Genesis (Chapters 6, 7 and 8) and of the Creation (Chapters 1 and 2). How

would you have felt about these discoveries if you had lived when people thought every word in the Bible was absolute truth?

2. Here is a way to study activity like that of a glacier right outside your window at home (suggested by John Roberts, in the Bulletin of the Children's Museum, Jamaica Plain, Mass.)

When the glaciers flowed down from the north they moved because the weight of the snow and ice piled several miles thick forced the lower layers of ice to move away from the places where the ice was the thickest. While this winter's snow will not be that thick we can measure the movement of a thick snowfall creeping off our porch roofs by putting several straws in lines: one line parallel to the wall of the house, and the other down the slope of the porch roof as shown in the pictures below.

Measure the distances shown once each day noting in your record whether the day was sunny or cloudy. This is the same method used by geologists to study the movement of glaciers in Alaska. There they found that the ice moved about 7 feet each day, and that speeds of 30 feet were common during warm summers. It would be interesting to see what speeds our miniature glaciers reach and we want to know if they travel faster on a warm day.

(Have your father help you, or use a bulkhead without help.)

7. Where the Past and Future Meet

We have been studying the ancient past as its story can be read in rocks formed at many different times on the ever-changing surface of the earth. There is one place in this country where the rocks and fossils are young (perhaps only tens of thousands of years old) and some are in the process of forming. This is in a chain of islands off the southern tip of Florida, where, as Rachel Carson tells us,

> Knowing the past, we can see in the present a repetition of the pattern, a recurrence of earth processes of an earlier day. Now, as then, living reefs are building up offshore; sediments are accumulating in shallow waters; and the level of the sea, almost imperceptibly but certainly is changing.

Florida and the Florida Keys are part of a large peninsula, much of which is under a warm shallow sea. Only a third of it is now above water. During the last Ice Age, which was about ten thousand years ago, the southern part of Florida rose from the sea. It is so near sea level that it has probably been under water several times as the level of the ocean rose and fell.

The Florida Keys are the remains of an old coral reef, built by the corals only a few tens of thousands of years ago. Then the level of the sea changed and, as the reef rose above the water, the coral-building animals died, leaving behind the reef that forms much of the rock of the islands.

Off the Florida shore more coral reefs are growing today. In the sheltered area between the reefs and the land, great beds of seaweed or algae are growing. The algae use a great deal of carbon dioxide. When the carbon dioxide is removed from the water, the lime settles to the bottom in a jelly-like ooze. This combines with sand, bits of shells, pieces of coral or whatever similar materials are on the sea bottom, and hardens into limestone. This is the same process that has made rocks containing fossils in many parts of our country.

Another place where you can almost see the past come to life is in the Everglades, a tropical swamp of southern Florida. Some parts of the Everglades are almost jungle. Here in the jungle-like areas are scrub palms much like those that grew in the days of the

dinosaur. Here there are giant ferns growing in the swamp, similar to fossil ferns that have been found in coal mines — like the ferns that lived at least 200 million years ago. Water snakes, turtles and alligators swim and climb in the swamp, looking very much like their ancient ancestors from the age of reptiles.

Florida has the fossil bones of many animals that were driven south when the ice sheet crept down over the northern part of the continent. There are no dinosaur bones in Florida, because the land area was under water when the dinosaurs lived. But mastodons, saber-toothed tigers and many such animals have left their bones behind in Florida.

It is important to remember that on the peninsula beyond Florida, under the warm shallow sea, rock is being formed today much as rock has been built through countless ages. This rock is a thick layer of limestone called oölite, made of thousands and thousands of tiny round grains of calcite cemented together. Another Florida rock is coquina, made of myriad tiny shells held together by the lime. Some of the Florida rock is in the new coral reef growing slowly off the coast. Florida is a place where you understand the present by remembering its ancient past and watch the processes that are building its future.

Something to Talk About and Do

Now that you have been studying fossils for several weeks would you like to plan a display so that you can share what you have done and learned with another class or your parents? Talk about what you want to include, what pictures you will use and how you will present it.

For Parents and Teachers

Through the study of fossils the child can see, from evidence he can hold in his hand, that the earth has undergone vast changes. By looking at lumps of coal, glacier-scratched rocks, stones with embedded sea shells or footprints in solid rock, he can begin to understand the changes from tropical swamps to glacier-covered fields, the extent of the inland sea, and also to comprehend a little of the way in which scientists have put together the pieces of this giant jigsaw puzzle to picture the parade of animals that have lived on our earth through the ages. These changes are very great, but they have come about through the slow orderly processes of nature over tremendous spans of time.

We all share a great curiosity about the world and its beginnings and an interest in its history. Nature is really so great a mystery that we may never be able to fully understand it. But in learning about fossils you can begin to study, and you can share the learning and the mystery with children.

Even if there is a fine museum nearby, you will want fossils right in the classroom, fossils the children can examine, feel, handle as much as they wish. There are two excellent sources:

1. A collection of ten fossils (identified) and a pamphlet about them, as well as the booklet *Life Through the Ages.* This can be purchased for $1.75 from the Chicago Natural History Museum Book Shop, Roosevelt Road, Chicago 5, Illinois.
2. Three sets can be purchased from the Edmund's Scientific Company, Barrington, New Jersey: Earth Scientists Set (mixed eras), No. 40,385; Carboniferous Set, No. 40,387; Cretaceous Set, No. 40,386. Ten specimens labeled in each, $1.25 pp. each. All three sets, No. 50,344; $3.75 pp.

Chapter 1

The main purpose of this lesson is to introduce children to fossils, and help them realize that these are very ancient things, preserved for us until today by the action of mud and silt and clay. They also will get a clearer picture of how this happened if they have made the casts and molds described in the children's section. The teacher will want to practice ahead of time with the plaster of

Paris, which is mixed with water to about the consistency of a cream soup and poured. It will harden quickly, so the whole class should have their objects ready, with the collars, before the teacher mixes the plaster. The horn coral and the sea urchin in the Chicago Museum set could be used for making molds and casts.

The teacher will want to work very slowly through the section of the lesson dealing with time concepts; these are difficult for children to grasp. Take the time to *do* the things.

For the fourth activity let the children "pore over" the set, or sets, of fossils (and check in books in the library), and then encourage them to try to make careful drawings as a scientist on a field trip might do.

Study the maps of the inland sea in Parker's *Stories Read from the Rocks* (see bibliography). If you are in an area where the inland sea covered the land, find out if a science teacher at the high school or nearby college will tell you where to hunt for fossils or, better yet, if he will take the children on a fossil hunt.

Chapter 2

The main point of this lesson is to deepen and broaden the children's comprehension of fossils and their place in the development of the world. Go over all you did last week in regard to time spans. A fairly large portion of the time will be spent in working with the chart which is at the center of this booklet. Talk about the four geologic eras that are named in the lesson; use these names as well as the simpler "Age of Fish," etc. Help them notice the developing complexity of life, the rising of the mountains, all the little details that they will probably see for themselves if you just keep on talking together. When the chart has been thoroughly explored, look up some of the animals in other books; the best source of pictures for this lesson is *The World We Live In* (see bibliography). You will also want to talk about how slowly scientists have collected all this material. Go over the things to do at home with the children.

The development of these concepts of the very great age of the earth, the increasing complexity of living things and the short time man has been dominant on the scene, are all important basic ideas for development.

Chapter 3

The point of this lesson is how Hall stuck to his views in spite of opposition. This holding to what you believe is an important

lesson. You will also want to talk more about the inland sea and how sediment sinks to the bottom, and help the children to realize how long it must have taken for this to become heavy enough to push the land down so that the mountains "buckled up." The slow changes of nature, imperceptible at the time but piling up over tremendous spans of time, is an important learning. Help the children to discuss these things. Discussion is the primary activity for this lesson, as it ties the two previous ones together into a meaningful whole. Go back and review the other lessons, if there is need. If no one performed the sedimentation experiment, it should be done in class; it will have "settled" into layers nicely by next week.

Chapter 4

The footprints left in the mud are not really "fossils" but are fossilized footprints. The difficulty people have in accepting new ideas is again an important item in this lesson. Help the children understand how ideas are always changing, how their ideas may change as they learn more.

The children will enjoy making the fossil "handprints," which is done just as the fossil casts were made. An ambitious teacher might want to mix some cement and make a series of stepping stones of the children's footprints, perhaps to use on the church grounds.

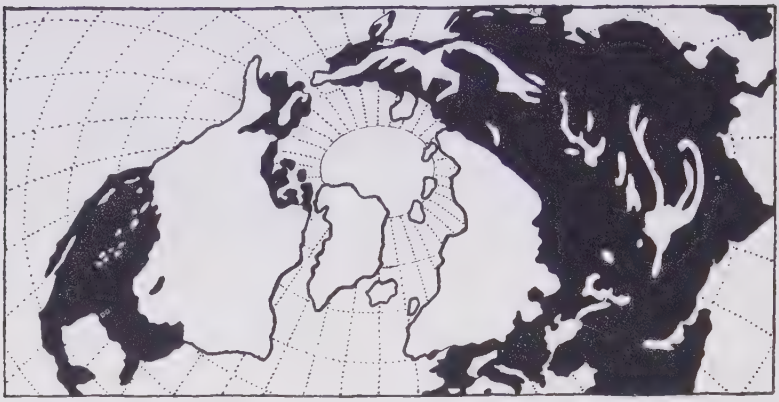
Borrow some books on animal tracks from the library. Stimulate the children's interest in track hunting during the week.

Chapter 5

This is a session that will fascinate the children and shows another way in which accident has preserved knowledge for us. This is a particularly good lesson for a mural and the class will find it interesting. There is a particularly well illustrated thirty-page pamphlet, *Let's Make a Mural,* by Marjorie Kelley and Nicholas Roukes (Fearon Publishers, 2263 Union St., San Francisco 23, California, $1.50), which will be invaluable for teachers with no experience in mural making. There is no better way of encouraging the children to study than when they are doing this to get knowledge for the mural. The mural will take more than one session to finish.

Chapter 6

Study this map of the last glacier with the children.



Pleistocene Glacier

Adapted from map, page 340, of G. S. Craig's Science for the Elementary School Teacher, *by permission of Ginn and Company*

Again the lesson centers on accepting new ideas. This is an excellent opportunity to deepen children's knowledge of ideas about the Bible. After the story of Agassiz has been read, *tell* the two stories from the Bible; encourage the children to read them with their parents at home. Then discuss why it was hard for people who believed that these stories were true to accept the idea of fossils, of a constantly (and still) changing earth and the glaciers of the Ice Age.

Talk about the "glacier experiment" to do at home. It would be wise to send postcards to parents mentioning the project and its relation to the lesson.

Chapter 7

Reading Chapter V of Rachel Carson's *The Edge of the Sea* (see bibliography) will give the teacher a fine background for this session. Deepen the concept of the never-ending change over countless ages, which is one of the main values of this study.

Any unit is strengthened by review through planning a closing program. The real value comes when it is the children's *own* program, in which they share their enthusiasm with others. They may want to have a play about Hall or Agassiz, or they may want to use their casts, molds, murals, etc., for an exhibit or series of talks by the children.

For the Teacher

CARSON, RACHEL. *The Edge of the Sea.* Boston: Houghton, 1955. $3.95. New Am. Lib. MD242. 50 cents.

Chapter V will be particularly useful to the teacher in connection with Chapter Seven, which deals with the Florida coast. It is beautifully written, and parts of it could be used for a worship service in connection with this chapter.

FENTON, C. L., AND FENTON, M. A. *The Fossil Book.* New York: Doubleday, 1958. $15.00.

Although expensive, this will be found in most libraries, its excellent illustration and detail make it most useful for the teacher. See also list appended to bibliography of specific illustrations from thirty-eight of the fifty states.

MOORE, RUTH. *The Earth We Live On.* New York: Knopf, 1956. $6.00.

Chapter VII on Agassiz and Chapter X on Hall will be most helpful to the teacher in connection with these sessions. This is a fascinating book in any event.

The World We Live In. Editors of *Life.* New York: Time, Inc. 1955.

Invaluable for its many and excellent pictures, particularly for material on the dinosaurs. Children will pore over this book again and again.

For the Children

DARLING, LOIS, AND DARLING, LOUIS. *Before and After Dinosaurs.* New York: Morrow, 1959. $2.95.

A particularly attractive book on dinosaurs, and especially useful for the material on evolution which it contains.

GEIS, DARLENE. *Dinosaurs and Other Prehistoric Animals.* New York: Grosset, 1959. $2.95.

Pictures are large and excellent. Introduction by personnel of American Museum of Natural History. This brings the "skeleton zoo" to children who do not live near a museum.

LAUBER, PATRICIA. *All About the Ice Age.* New York: Random, 1959. $1.95.

Although this book has some inadequacies, it will be useful for the chapter which contains material on Agassiz and his study of glaciers.

PARKER, BERTHA MORRIS. *Stories Read from the Rocks.* Evanston, Ill.: Row Peterson, 1941. Basic Science Series.

Contains materials on fossils, glaciers and the inland sea. Excellent illustrations, and back cover has two maps of the inland sea.

RICHARDS, HORACE A. *The Story of Earth Science.* Philadelphia: Lippincott, 1960. $3.75.

Excellent introduction to earth with emphasis on fossils, rocks, and minerals. Drawings and bibliography especially helpful.

ROCKCASTLE, VERNE N., AND SCHMIDT, VICTOR E. *Ancient Sea Life,* a

Cornell Science Leaflet. N.Y. State College of Agriculture, (Vol. 52, No. 2), Cornell University, Ithaca, New York. 35¢.

An excellent leaflet on ancient sea life written for children. Although specific to New York State in large part, it will be useful in other areas. Two maps showing the inland sea in New York State and one map for the whole country in Jurassic times.

SHUTTLESWORTH, DOROTHY. *Age of Reptiles.* New York: Doubleday, 1958. $2.50.

This is also an excellent book on dinosaurs.

Book prices are subject to change, so it is advisable to check the current *Books in Print* at your library for the latest information.

GEOGRAPHIC DISTRIBUTION OF FOSSILS IN NORTH AMERICA

Partial listing of states and provinces from which there are illustrations of specific fossils in the Fentons' *The Fossil Book.* Only one page reference is given for each; in most cases there are many more.

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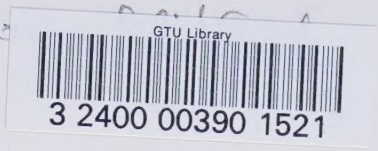

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